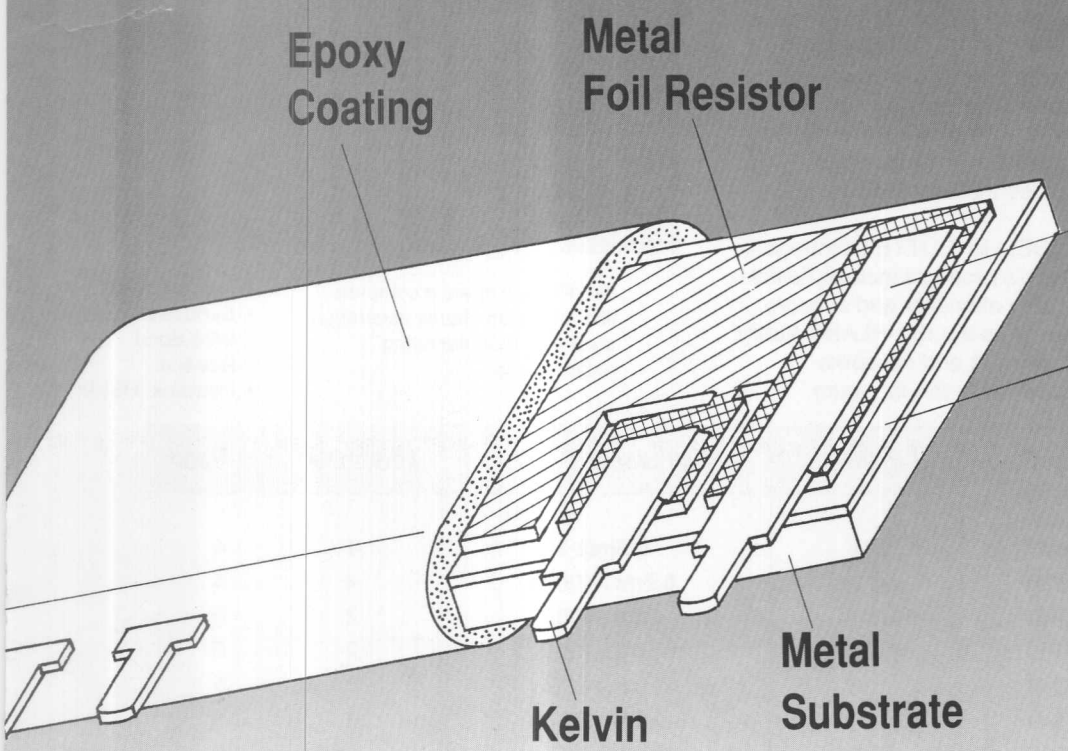
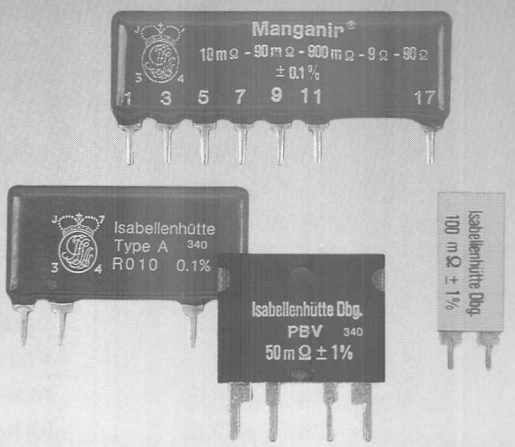
ISA-PLAN®

PRECISION CURRENT SENSING RESISTORS AND NETWORKS

Current sensing up to 250 Watts

- **Very low temperature coefficient of resistance**
- **Negligible inductance**
- **Low thermal emf against copper**
- **High load capacity**
- **Excellent long term stability**





ISOTEK CORPORATION

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ISABELLENHÜTTE

Advanced Solutions...
An ISABELLENHÜTTE Tradition

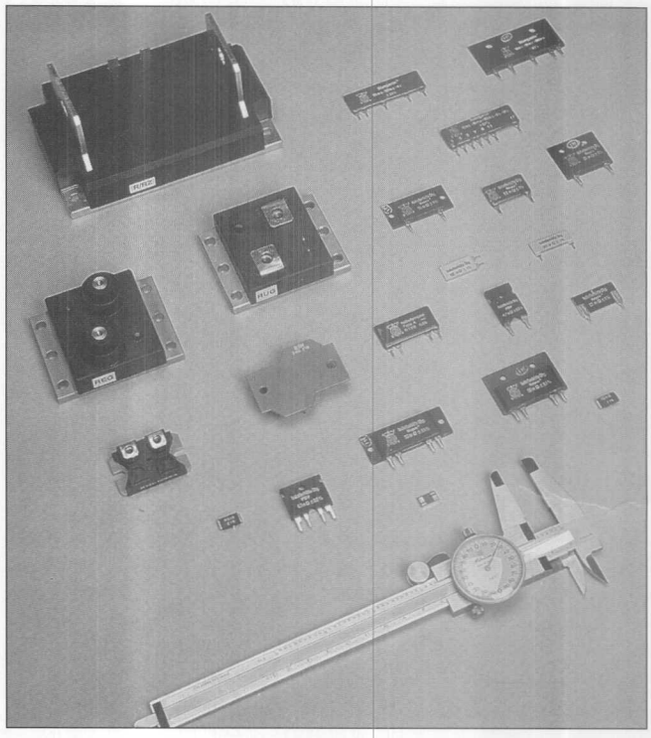
For over 500 years, ISABELLENHÜTTE of Dillenburg, Germany has a tradition of non-ferrous metal smelting and processing.

The eventful history of ISABELLENHÜTTE has always been directed by the drive and imagination of energetic people setting new industry standards. Today, ISABELLENHÜTTE is regarded as one of the world's leading manufacturers of electrical resistance and thermal materials. Their vast experience in creating these alloys dates back to the middle of the previous century when ISABELLENHÜTTE first supplied copper-nickel and copper-manganese alloys. Today's product line includes a broad range of time-proven and recently developed alloys which meet increasingly demanding requirements.

High Performance Through Technology...

Miniaturization and modern manufacturing processes put greater demands on resistance alloys. ISABELLENHÜTTE meets these demands through vertical integration. This allows complete control at all stages of the manufacturing process. Every step from smelting the alloys to testing the finished product is under control of the quality assurance department. ISABELLENHÜTTE manages a calibration lab under the auspices of the German Calibration Service (DKD - Deutscher Kalibrierdienst) which is subject to supervision by the national bureau of standards (Physikalisch-Technische Bundesanstalt — PTB).

ISABELLENHÜTTE Component Group's products include flexible heating elements and sensors, as well as the ISA-PLAN® family of resistors and networks described in this literature.



ISA-PLAN® offers a complete line of current shunts covering all electronic manufacturing technologies:

- Through Hole
- Surface Mount
- Wire Bond
- Bus Bar
- Heatsink (HS) Mount

Mounting	Model	Power	Resistance Range	Terminals	Page
BUS BAR	PVG	5 W	0.5mΩ-1Ω	4	4
BUS BAR	BSH	30 W	0.5mΩ-100mΩ	4	4
THRU-HOLE	PS	0.5 W	5mΩ-100Ω	2	5
THRU-HOLE	PL	0.5 W	5mΩ-100Ω	2	5
THRU-HOLE	C-N	1 W	2.5mΩ-100Ω	2	5
THRU-HOLE	A-N	1 W	0.5mΩ-100Ω	4	5
THRU-HOLE/HS	PBH	10 W	2.5mΩ-100Ω	2	5
THRU-HOLE/HS	PBV	10 W	1mΩ-100Ω	4	5
THRU-HOLE/HS	A-H1	10 W	0.5mΩ-100Ω	4	5
THRU-HOLE/HS	A-H2	10 W	0.5mΩ-100Ω	4	5
SMD	SMR	1 W	8mΩ-100Ω	2	5
SMD	SMV	1 W	3mΩ-100Ω	4	5
HYBRID	PMA-Cu	1 W	3 mΩ-500mΩ	4	6
HYBRID	PMB-Cu	2.5 W	1mΩ-1Ω	4	6
THRU-HOLE	IWN-A-N	1 W	Network	4	6
THRU-HOLE	IWN-A-H	4 W	Network	4	6
BASE/HS	RTO	50 W	0.2 mΩ-100Ω	2 & 4	7
BASE/HS	RUG	100 W	1 mΩ-100Ω	4	7
BASE/HS	REG	250 W	1 Ω-1500Ω	2	7

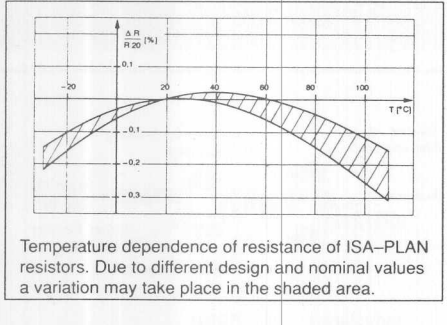
ISA-PLAN® Precision Current Sensing Resistors

ISA-PLAN® precision resistors are ideal for sensing and controlling current. ISA-PLAN® resistor elements are etched from rolled Manganin or optional Zeranin® foil. The foil is then laminated to a substrate resulting in a planar geometry which is ideal for high power dissipation and low inductance. Special annealing and manufacturing processes guarantee low temperature coefficient of resistance and excellent long-term stability.

Manganin, Zeranin® and Temperature Coefficient of Resistance...

All conducting materials change resistance in response to temperature. This is typically non-linear but it is usually approximated by a straight line between two temperatures. The slope of the line is known as the temperature coefficient of resistance or "TCR."

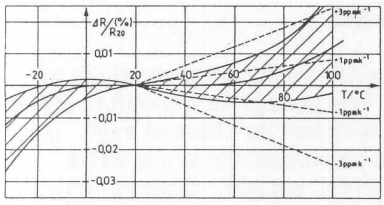
Manganin was first developed by ISABELLENHÜTTE about 100 years ago and is the standard resistance material in the ISA-PLAN® family. Its resistance response to temperature is given in the shaded region in the figure below. From 20 to 60°C the tcr is 10 ppm/°C. From 60 to 100°C it is 25 ppm/°C. Unless otherwise noted, tcr values for resistors are for Manganin alloys.



Temperature dependence of resistance of ISA–PLAN resistors. Due to different design and nominal values a variation may take place in the shaded area.

Manganin's resistive response to temperature. Shaded area denotes DIN 46460 allowable tolerance.

Zeranin® was first produced in 1965 by ISABELLENHÜTTE and is available as an option on the ISA-PLAN® product line. Its resistance response to temperature is shown below. It is approximately one order of magnitude less responsive to temperature than Manganin. It offers a tcr of 3 ppm/°C from 20 to 100°C and on the RUG resistor it is available with a tcr of 1 ppm/°C over this temperature range.

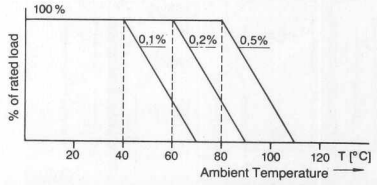


Zeranin's® resistive response to temperature.

Power Rating...

Resistors convert electrical energy to thermal energy according to Ohm's law: $P=EI=I^2R$ where P is power in watts, E is the voltage drop across the resistor, I is the current and R is the resistance. The resistor must dispose of the heat generated. Equilibrium is achieved when the heat generated is equal to the heat disposed and a stable internal temperature results. This temperature must not exceed a limit which varies depending on resistor technology. If this temperature is exceeded the stability will be compromised or the the resistor could be destroyed. For ISA-PLAN® technology, the maximum recommended continuous foil temperature is 125°C. The resistors are burned in at 140°C during manufacturing to assure stable long-term resistance when operating at 125°C.

From the foil, heat flows away through radiation and convection to the air and through conduction through the terminals. Resistors designed for heat-sink mounting can dissipate greater power than air-cooled devices by increasing the area for conduction to occur. For Manganin resistors designed for board mounting with no external heat sink (A-N, C-N, PL, PS, PLC, and SM) the power derating curve below applies. For resistors designed to be mounted to a heat sink, the internal thermal resistance is well characterized and given in this literature for thermal analysis. Isotek can provide technical support if required.



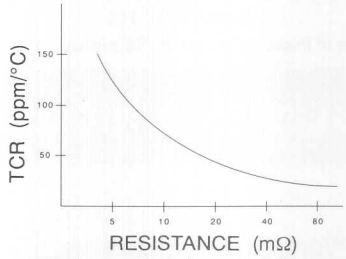
Power derating curves for air cooled resistors of different tolerances.

Pulse Power...

The unique laminated construction makes ISA-PLAN® particularly adept at handling pulsed power by increasing the effective thermal mass of the resistance element. A factor of 10 times the continuous power rating is generally acceptable for pulses up to one second in duration. This varies somewhat with the specific resistor package and with the duty cycle of the pulse.

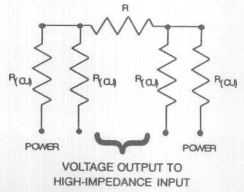
Kelvin Connection...

Kelvin or four-terminal connection is recommended for low-ohmic current sensing resistors. The lower in ohmic value, the more strongly it is advised. This is because the copper terminals become an ever increasing part of the overall resistance as the value decreases. The tcr of copper is around 4000 ppm/°C. This produces a large variation in effective resistance as the temperature of the resistor changes. This influence is illustrated by the graph below showing how the benefit of 10 ppm/°C Manganin is diminished by the copper when the resistance drops below about 80 mΩ in a two terminal resistor.



Rising TCR due to effect of copper with decreasing resistance.

This problem is eliminated with Kelvin connections where the voltage drop is measured on the resistor itself and directed to a high-impedance source. The TCR is only a function of the Manganin or Zeranin® resistance material. ISA-PLAN® four-terminal resistors have the Kelvin connections etched directly to the resistive element.



Kelvin measurement.

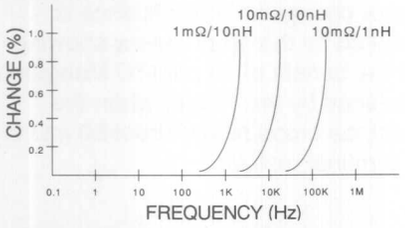
ISA-PLAN® Precision Current Sensing Resistors

Reactance, Impedance & Inductance...

The presence of capacitance or inductance in an AC circuit produces a phase shift between the current and voltage known as reactance. Impedance is the ratio of effective voltage divided by effective current in an AC circuit. In low ohmic resistors, the effect of inductive reactance dominates. While the inductance of the resistors described in this literature are typically less than 10 nH, mounting and wiring or trace layout can increase the effective inductance. The total impedance (which determines the resulting measured voltage drop) is given by:

$$Z = [R^2 + (2\pi fL)^2]^{0.5}$$

A 1 mΩ resistor with a net inductance of 10 nH produces an error in measurement of 1 % at a frequency of 2.23 kHz. The figure below illustrates the relationship between frequency, inductance and resistance. The error increases with increasing frequency and decreasing resistance.



Change of Impedance versus Frequency

Thermal EMF...

Dissimilar metals in contact produce a voltage. This voltage varies with temperature and is known as "thermal emf". This emf must be considered in low value resistors in DC circuits. Copper, the terminal material, is used as the reference metal. Manganin and Zeranin® have low thermal emfs of <2 μV/°C with copper. One side of the resistor is a +2 μV/°C generator and the other side is a -2 μV/°C generator. Ideally, both ends of the resistor are at the same temperature and the thermal emfs cancel. The low thermal emfs of Manganin and Zeranin® minimize this influence on the measurement, but it is up to the user to assure that the resistor is not being non-uniformly heated by other components in the application. Since measurements are generally above 50 mV, a few degrees of differential temperature will not affect the accuracy materially.

Noise...

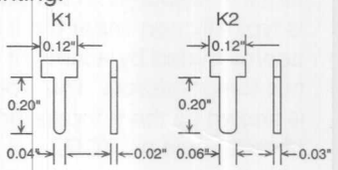
Noise is any undesired signal from the resistor. Noise in ISA-PLAN® metal foil resistors is primarily due to thermal effects. Thermal noise comes from random electron motion in the resistive material resulting in a small and fluctuating potential difference across the terminals. This is given by the equation:

$$E=[4KTR(f2-f1)]^{0.5}$$

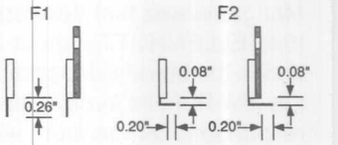
where K is Boltzmann's constant, T is the absolute temperature in Kelvin, R is the resistance and (f2-f1) is the bandwidth in Hertz. Typically, this noise is less than a few μV and can be ignored in most applications.

Terminals and Current Limits...

For through-hole resistors, the standard terminal is shown as K1 below. For applications over 35 amps, the optional K2 is recommended up to 80 amps. (PBH and PBV have K2 power terminals as standard.) For over 80 amps, the high-power packages with screw terminals or buss bar mounting is recommended. Type F2 terminals are available for horizontal mounting.



Type of Terminals



Connection Types

Ordering Notes...

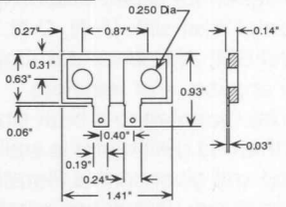
1. An "R" is used in place of the decimal to avoid its loss.
2. Manganin is the standard resistance material. To specify Zeranin® material, place a "-Z" after the package designation.

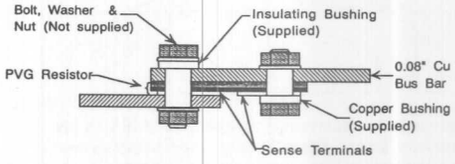
EXAMPLE: BSH-Z-R001-1.

Bus-Bar Mounted

The PVG and BSH resistors are ideal for use in high-current power supplies, UPS equipment and motor drives. Both packages are designed to be integrally mounted into the current-bus structure. This results in a mechanically rigid construction as well as space savings and assembly convenience. This unique design enables the current bus to also serve as heat-sink.

MODEL PVG 10 WATT/FOUR-TERMINAL (50 ppm/°C)

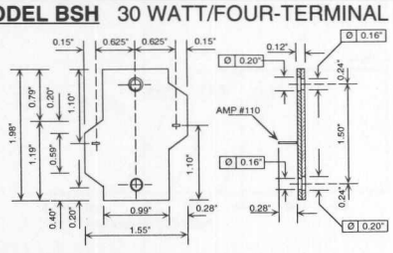


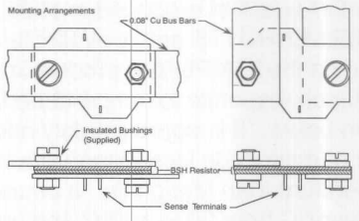


Resistance Range: 0.5 mΩ-1Ω
Tolerance: 0.5, 1.0, 2.0%
Ordering Example: PVG-R001-1 (1 mΩ/1.0%)

Inductance: 4 nH (R010)
Internal Heat Resistance: 5 °C/Watt

MODEL BSH 30 WATT/FOUR-TERMINAL (10 ppm/°C)





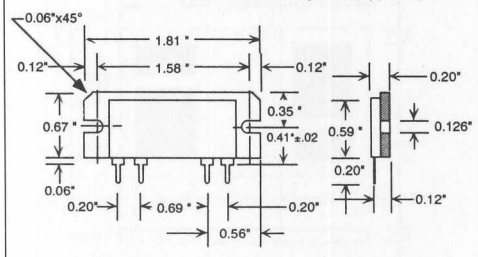
Resistance Range: 0.5 mΩ - 100 mΩ
Tolerance: 0.1, 0.2, 0.5, 1.0
Ordering Example: BSH-R001-1 (1 mΩ/1.0%)

Inductance: 0.5 nH
Internal Heat Resistance: 1.5 °C/Watt

Through-Hole

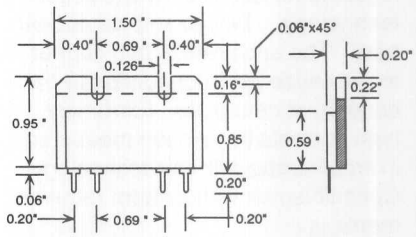
Through-hole resistors are available in packages ranging from 0.5 watts to 10 watts of power dissipation. The PBH/PBV resistors are recommended for general purpose use while the A-series is recommended where exceptional accuracy and tcr performance is required.

MODEL A-H1 7 WATT (off heatsink)
10 WATT (on heatsink)
FOUR-TERMINAL (TCR: 10 ppm/°C)



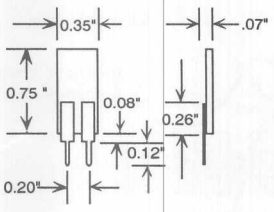
Resistance Range: 0.5 mΩ-100Ω
Tolerance: 0.05, 0.1, 0.2, 0.5, 1.0%
Internal Heat Resistance: 3.6°C/Watt
Ordering Example: A-H1-R220-F1-K1-1 (220 mΩ/1.0%)

MODEL A-H2 7 WATT (off heatsink)
10 WATT (on heatsink)
FOUR-TERMINAL (TCR: 10 ppm/°C)



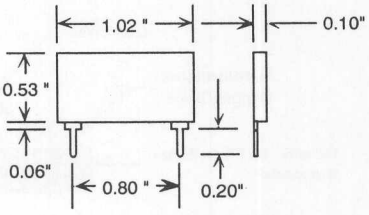
Resistance Range: 0.5 mΩ-100Ω
Tolerance: 0.05, 0.1, 0.2, 0.5, 1.0%
Internal Heat Resistance: 3.6°C/Watt
Ordering Example: A-H2-R220-F1-K1-1 (220 mΩ/1.0%)

MODEL PS 0.5 WATT
TWO-TERMINAL



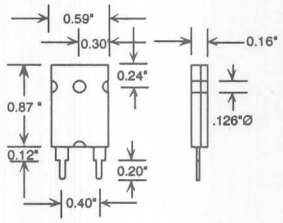
Resistance Range: 5 mΩ-100Ω
Tolerance: 0.5, 1.0, 2.0%
Ordering Example: PS-R220-1 (220 mΩ/1.0%)

MODEL C-N 1.0 WATT
TWO-TERMINAL



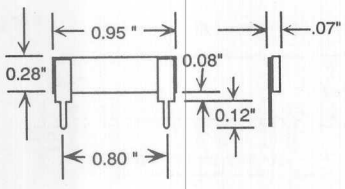
Resistance Range: 2.5 mΩ-100Ω
Tolerance: 0.1, 0.2, 0.5, 1.0%
Ordering Example: C-N-R220-F1-K1-1 (220 mΩ/1.0%)

MODEL PBH 6.0 WATT (off heatsink)
10 WATT (on heatsink)
TWO-TERMINAL



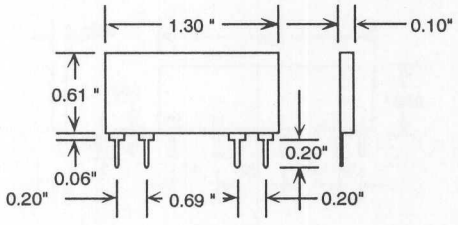
Resistance Range: 2.0 mΩ-100Ω
Tolerance: 0.5, 1.0, 5.0%
Internal Heat Resistance: 4°C/Watt
Ordering Example: PBH-R220-5 (220 mΩ/5.0%)

MODEL PL 0.5 WATT
TWO-TERMINAL



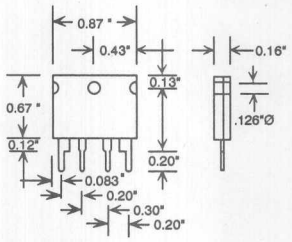
Resistance Range: 5 mΩ-100Ω
Tolerance: 0.5, 1.0, 2.0%
Ordering Example: PL-R220-1 (220 mΩ/1.0%)

MODEL A-N 1.0 WATT
FOUR-TERMINAL (TCR: 10ppm/°C)



Resistance Range: 1.0 mΩ-100Ω
Tolerance: 0.1, 0.2, 0.5, 1.0%
Ordering Example: A-N-R220-F1-K1-1 (220 mΩ/1.0%)

MODEL PBV 6.0 WATT (off heatsink)
10 WATT (on heatsink)
FOUR-TERMINAL (TCR: 30 ppm/°C)

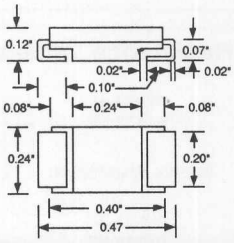


Resistance Range: 1.0 mΩ-100Ω
Tolerance: 0.5, 1.0, 5.0%
Internal Heat Resistance: 3.7°C/Watt
Ordering Example: PBV-R220-5 (220 mΩ/5.0%)

Surface Mount

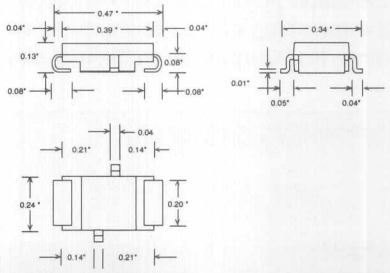
These are the first low-ohmic resistors fully compatible with surface mounting and soldering equipment. Both are supplied in embossed 24 mm carrier tape per EIA-481 for automatic mounting.

MODEL SMR 1.0 WATT
TWO TERMINAL



Resistance Range: 8 mΩ-10 Ω
Tolerance: 1.0, 2.0, 5.0
Ordering Example: SMR-R220-1 (220 mΩ/1.0%)

MODEL SMV 1.0 WATT
FOUR TERMINAL (TCR: 30 ppm/°C)

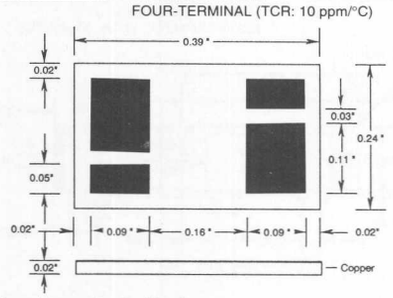


Resistance Range: 3 mΩ-10 Ω
Tolerance: 0.5, 1.0, 2.0, 5.0
Ordering Example: SMV-R220-1 (220 mΩ/1.0%)

Wire-Bondable

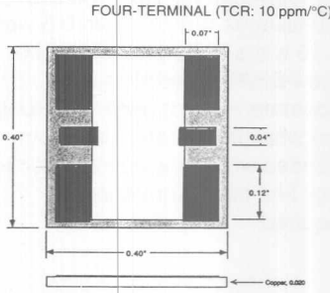
ISOTEK has developed sense resistors for use with hybrid circuit technology . Two examples appear here. The substrate is thin copper to maximize heat conduction to the ceramic or cold-plate. Extremely high currents have been measured in small areas with this technology. Consult Isotek with custom requirements.

MODEL PMA-Cu 1.0 WATT TYPICAL
FOUR-TERMINAL (TCR: 10 ppm/°C)

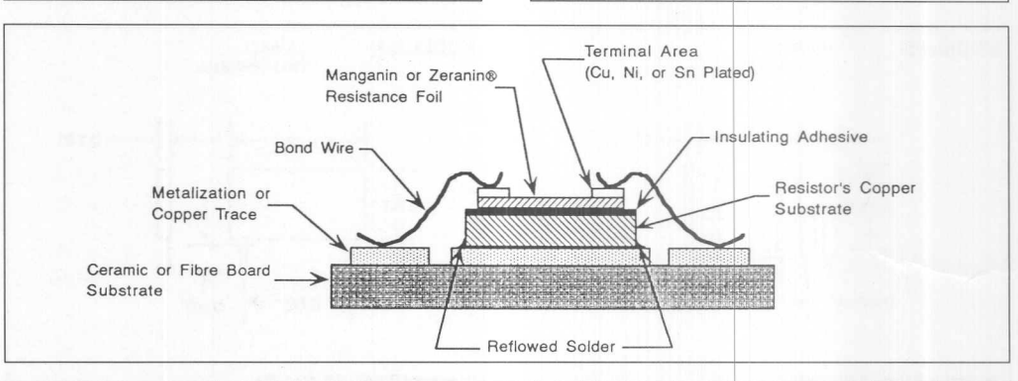


Resistance Range: 3 mΩ - 50 mΩ
Tolerance: 0.5, 1.0, 2.0, 5.0
Internal Heat Resistance: 5°C/Watt
Ordering Example: PMA-Cu-R005-5 (5 mΩ/5.0%)

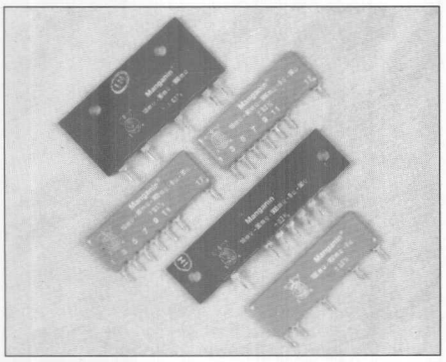
MODEL PMB-Cu 2.5 WATT TYPICAL
FOUR-TERMINAL (TCR: 10 ppm/°C)



Resistance Range: 1 mΩ - 50 mΩ
Tolerance: 0.5, 1.0, 2.0, 5.0
Internal Heat Resistance: 2°C/Watt
Ordering Example: PMB-Cu-R005-5 (5 mΩ/5.0%)

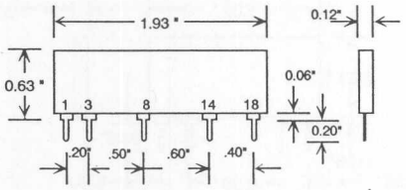


ISA-PLAN® Precision Current Shunt Networks

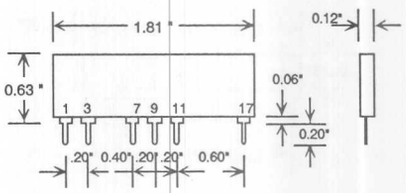


ISA-PLAN® resistor networks were specially designed for application in digital and analog current measuring and regulation devices in which the current must be measured over a range of several orders of magnitude. Since each resistor element is etched from the same physical section of metal foil, the matching of the resistors to each other is unsurpassed in the industry.

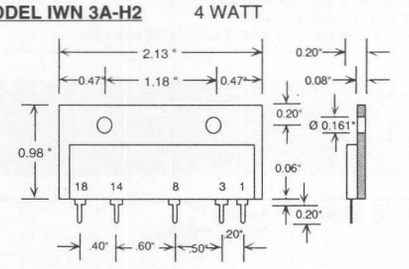
MODEL IWN 3A-N 1 WATT



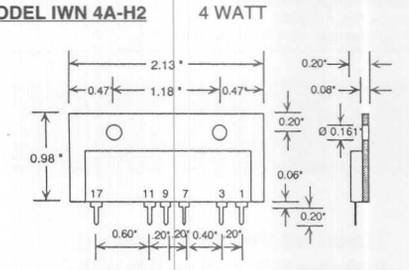
MODEL IWN 4A-N 1 WATT



MODEL IWN 3A-H2 4 WATT



MODEL IWN 4A-H2 4 WATT

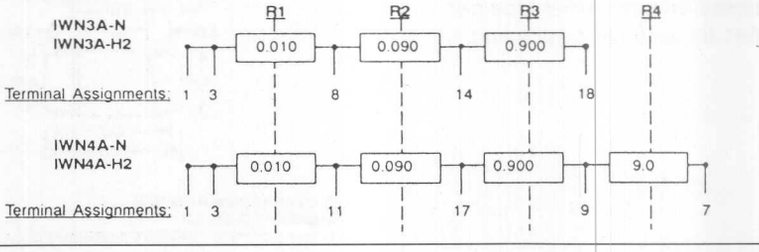


ORDERING EXAMPLE:

IWN 3A-H2 - F2 - 0.2

Model
Connection Type
Tolerance (%)

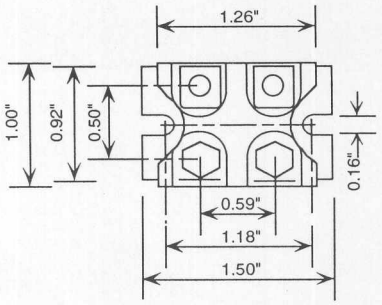
Resistance Values and Schematic for Terminal Assignment

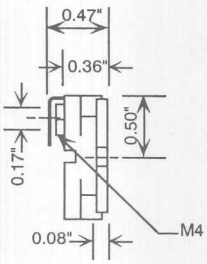


High-Power Screw Terminal Base-Mount

MODEL RTO

50 WATT. . .
The RTO is identical to the SOT227B "ISOTOP" package (TO-238). With 2500 VAC isolation to the base, the resistor can be operated at the high side of the AC line. The RTO is ideal for use as a current sense resistor or as a power resistor in snubber RC-bypass for protection of transistors and thyristors. The heavy copper terminals allow continuous currents up to 200 A and short pulse currents to 1500 A. The RTO is available in two, three, and four terminal configurations with single, double or triple resistors.



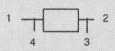


Resistance Range: 0.2 mΩ - 100 Ω
Inductance: 6 nH (R010)
Tolerance: 1.0, 2.0, 5.0%
Weight: 1 ounce
Internal Heat Resistance: 1.5°C/Watt
TCR: 50 ppm/°C Manganin; 20 Zeranin
Ordering Examples: For Configuration A or B: RTO-A-R010-1 (10 mΩ/1.0%)
For Configuration C to G: List Pin Connections for Different Resistance Values: RTO-G-(1-3)R001-(3-4)R010-(4-2)R100-1

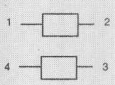
AVAILABLE CONFIGURATIONS

A

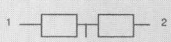

Two-terminal Resistor

B


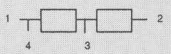
Four-terminal Resistor

C


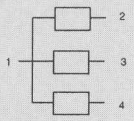
Two separate Two-terminal Resistors

D


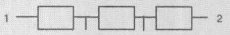
Double Resistor

E


Resistor Network (Low ohmic resistor in four-terminal connection)

F


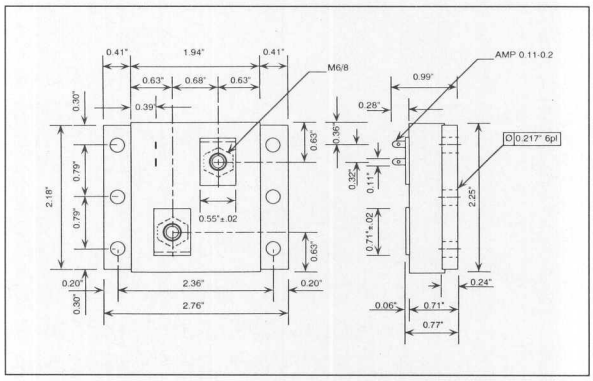
Triple Resistor Ideal for sense resistors, or as power resistors in smubber RC-bypass

G


Triple Network

MODEL RUG

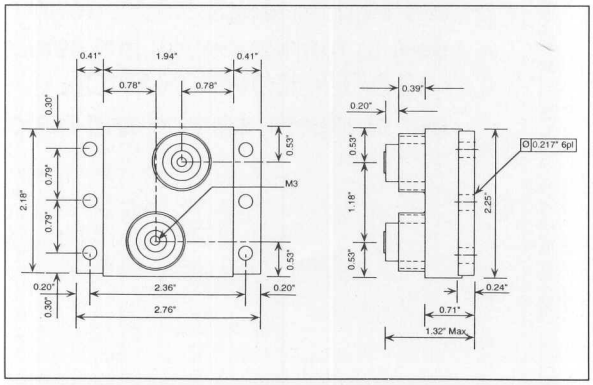
100 WATT . . .
Designed for high DC and low frequency AC current, the RUG's package geometry is common to high power transistor modules. In this package, Zeranin® can be specified at a 3 ppm/°C or 1 ppm/°C tcr. Manganin is standard at 10 ppm/°C.



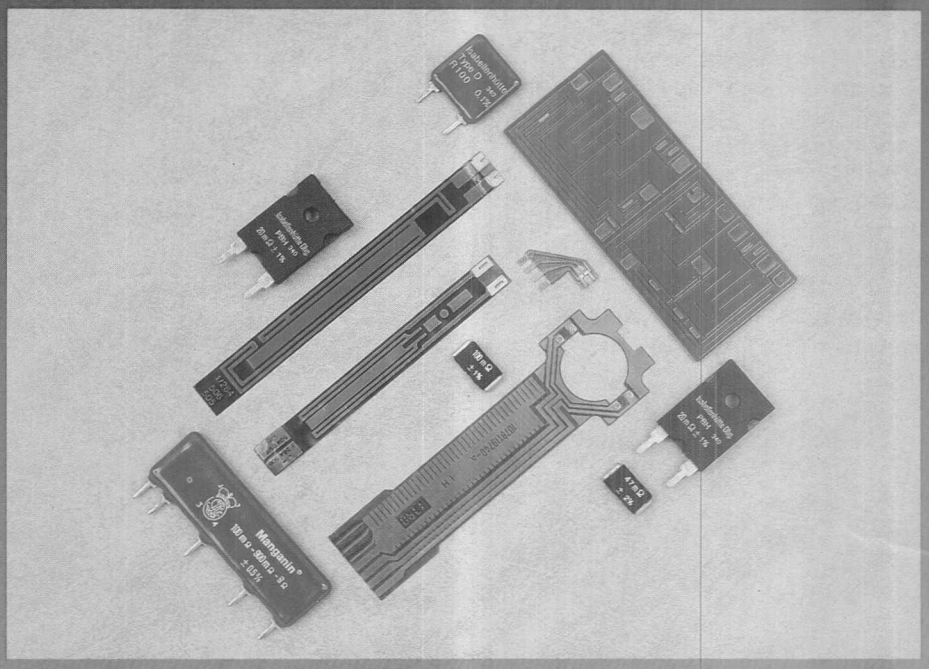
Resistance Range: 1 mΩ to 1 Ω
Inductance: 9 nH (R010)
Tolerance: 0.1, 0.2, 1.0%
Weight 9.3 ounces
Internal Heat Resistance: 0.3 °C/Watt
Ordering Example: RUG-R050-1 (50 mΩ/1.0%)

MODEL REG

250 WATT . . .
The REG is a high power, high isolation (5000 Volts AC to base) resistor that has been specially developed for RC snubber protection. It can withstand instantaneous pulse power up to 2 kW. The resistive element is directly bonded to a ceramic plate that is again bonded to the copper base plate. This construction guarantees a very low internal heat resistance of less than 0.1 °C/Watt and high isolation.



Resistance Range: 1 Ω to 1500 Ω
Inductance: 400 nH (22R0)
Tolerance: 0.1, 0.5, 1.0, 5.0%
Weight 9.5 ounces
Ordering Example: REG-100R-1 (100Ω/1.0%)



Special Thermo-Pile Sensors, Heating Elements and Resistor configurations are available. Contact your ISOTEK specialist to discuss your application.

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